



JET ENGINE NOISE REDUCTION

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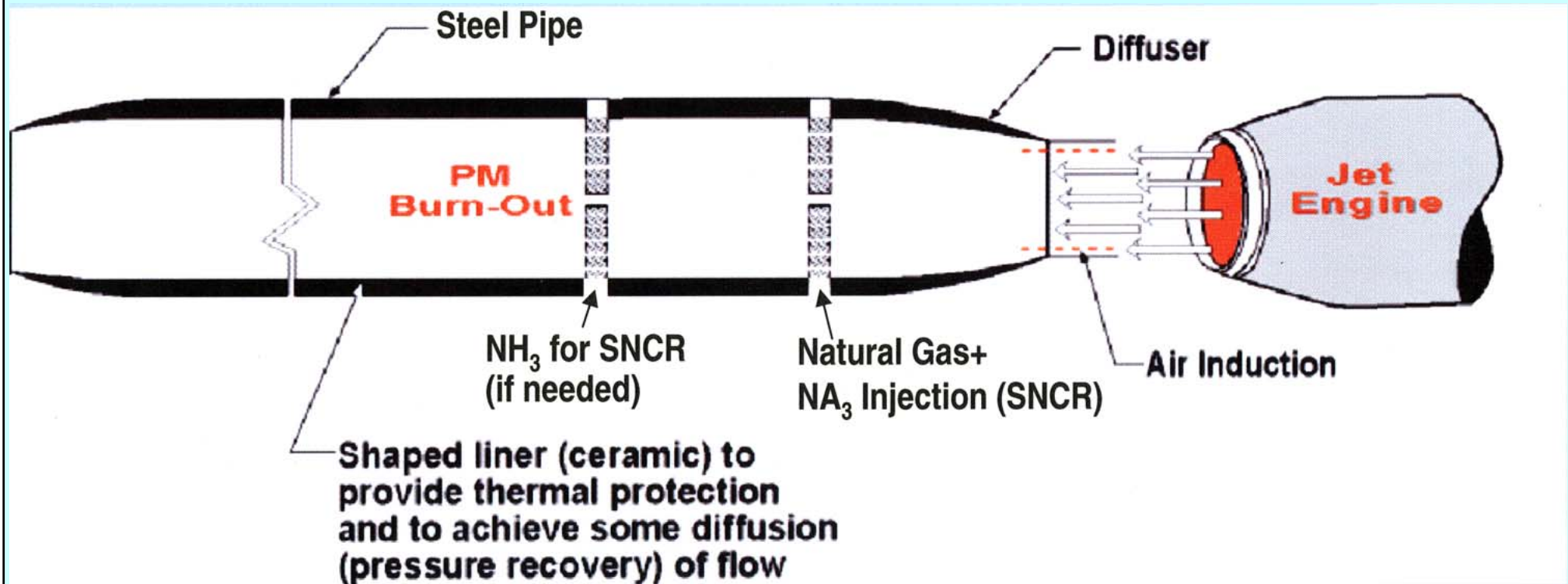
***YO817 PROJECT REVIEW
17-19 May 2004
Port Hueneme, CA***



Introduction

- **Noise Reduction Objective: Full scale noise reduction of 20 dbL.**
 - **Primary Driver: Noise Control Act, NEPA, Executive Order 13148, DoD Instruction 4165.57, state and local regulations**
 - **Priority: High**
- **NOx Reduction Objective: Reduce JETC NOx emissions by 50%.**
 - **Primary Driver: National Environmental Policy Act, CAA conformity requirements, Executive Order 13148, state and local regulations**
 - **Navy EQ Requirement: 2I.01.f Control Emissions from Jet and Rocket Engine Testing.**
 - **Priority: High**

ANNULAR AFTER REACTOR



Technology Descriptions

- **NOISE REDUCTION**

- **AAR**
- **AAR + Fluid Flow Diversion**

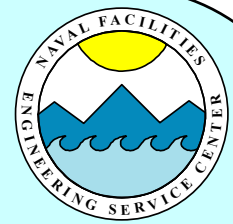


- **NO_x REDUCTION**

- **Annular After Reactor (AAR) with Selective Non-Catalytic Reduction (SNCR) of NO_x using NH₃**
- **AAR from SERDP project**
- **SNCR is a well-developed technology from utility industry**

AAR WITH SEVEN REACTOR SEGMENTS





Benefits/Payback

NOISE REDUCTION (Pollution Prevention/Compliance)

- **Significant noise reductions have been demonstrated when using the AAR.**
 - **Subscale (laboratory scale) AAR (10 - 20 dbL)**
 - **Small-scale (small drone jet engine) AAR (12 - 35 dbL)**
 - **Full-scale AAR demonstration showing 20. dB noise reduction will provide alternative noise reduction technology for ground testing of Navy aircraft for \$150.K vs. \$15.M for new JETCs.**

NOx REDUCTION (Pollution Prevention/Compliance)

- **No other NOx reduction technology has proven technically or economically feasible for JETCs.**
- **The AAR is a new concept being evaluated for this application.**
- **50 % NOx reduction could be possible at relatively low cost.**

Milestones



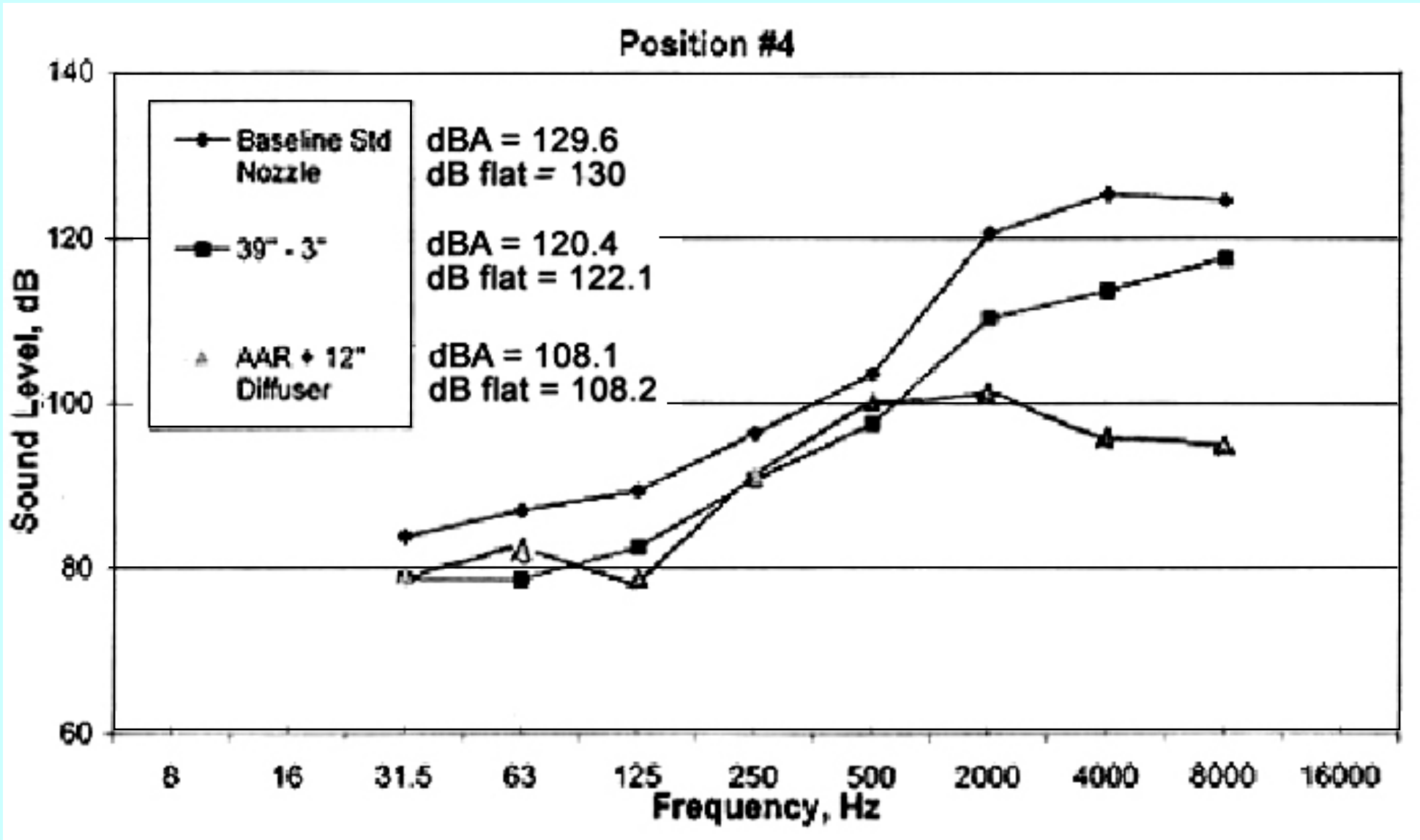
	<u>Planned</u>	<u>Actual</u>
Complete Sub-scale Noise tests	06/01	10/01
Complete Sub-scale NOx tests	02/01	11/01
Complete Small-scale Noise tests	02/02	07/02
Complete Small-scale NOx tests	07/01	09/02
Select Test Site for Full-scale AAR Noise tests	06/03	02/04
Complete design of Full-scale AAR (Noise)	09/03	04/04
Fabricate Full-scale AAR (Noise)	02/04	
Install Full-scale AAR at test site (Noise)	06/04	
Complete Full-scale Tests (Noise)	08/04	
User Data Package	10/04	
Complete Test Report	10/04	



Accomplishments To Date

- **Demonstrated AAR noise reductions at two engine scales:**
 - **Sub-Scale (simulated engine) 10 – 21 dB reduction**
 - **Small-Scale Drone Engine (12' AAR length) 12 – 35 dB reduction**
 - **Small-Scale Drone Engine (35' AAR length) TBD**
- **Demonstrated AAR noise attenuation is broad-band and is centered about the frequency of peak noise production (η_p), regardless of engine size.**
- **Designed full-scale AAR for noise attenuation of Navy F414 / F404 engines. Contract for fabrication in progress. Negotiated full-scale testing of AAR at Patuxent River NAWC MD, for June / July 2004.**
- **Based upon small scale test results CFD modeling of SNCR/AAR reactions for F404 engine showed full-scale NOx reductions of up to 60.%**

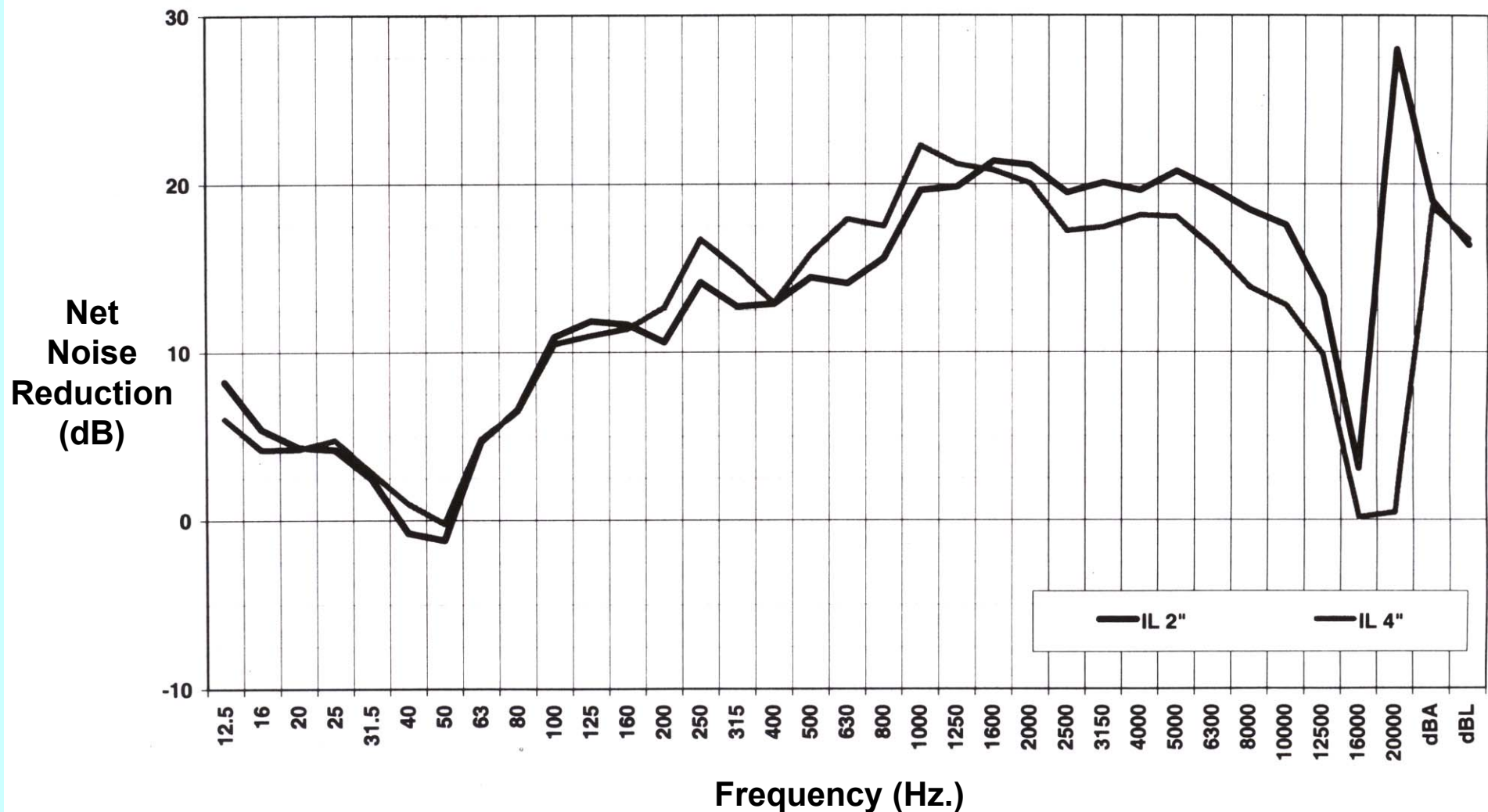
Sub-Scale AAR Noise Measurement Results



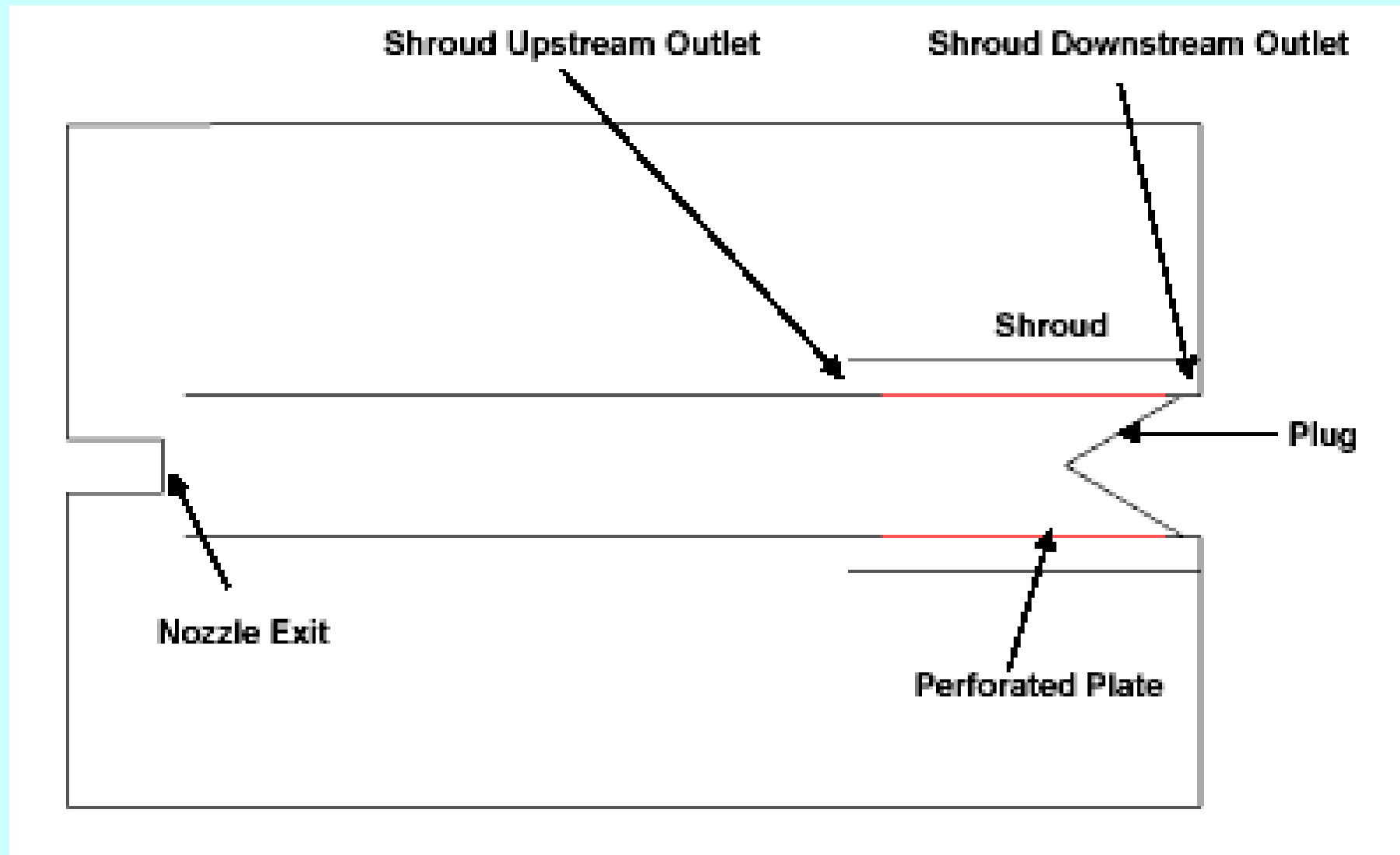
Small-Scale AAR Broad-Band “Net” Noise Reduction



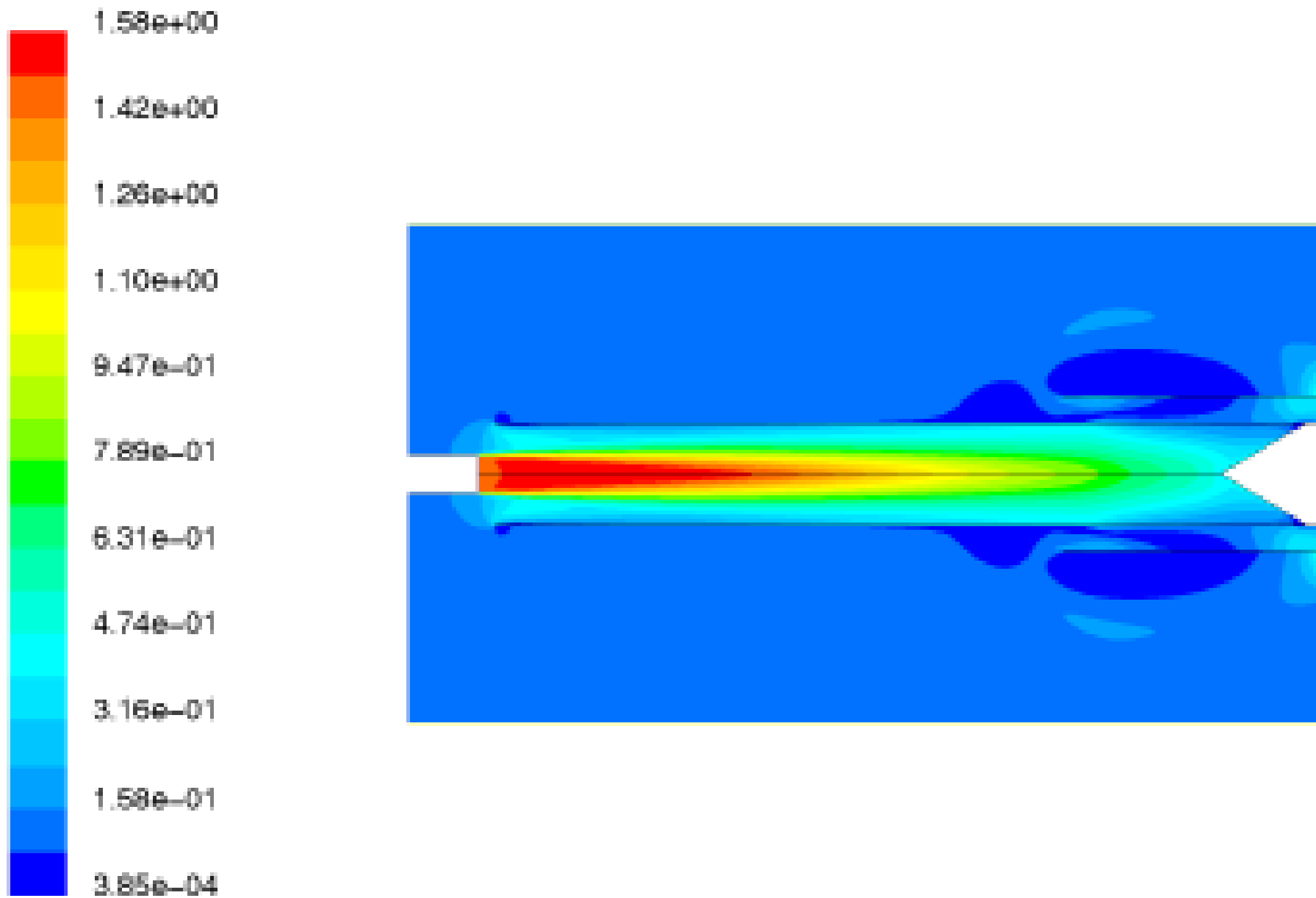
Microphone Position 4



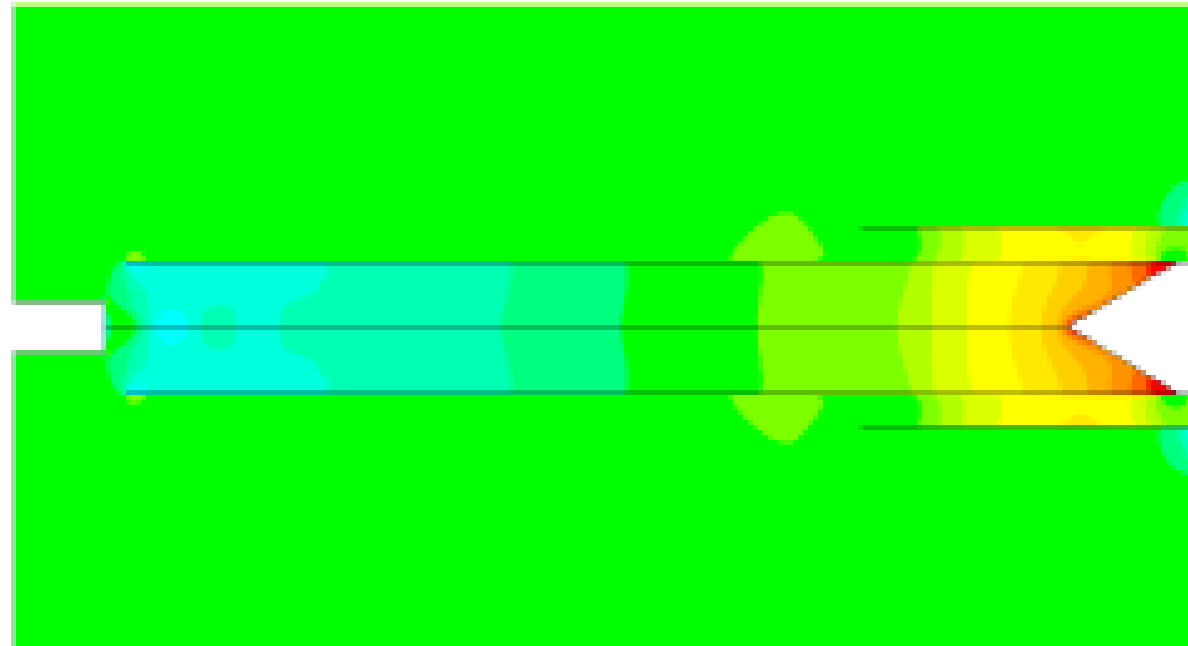
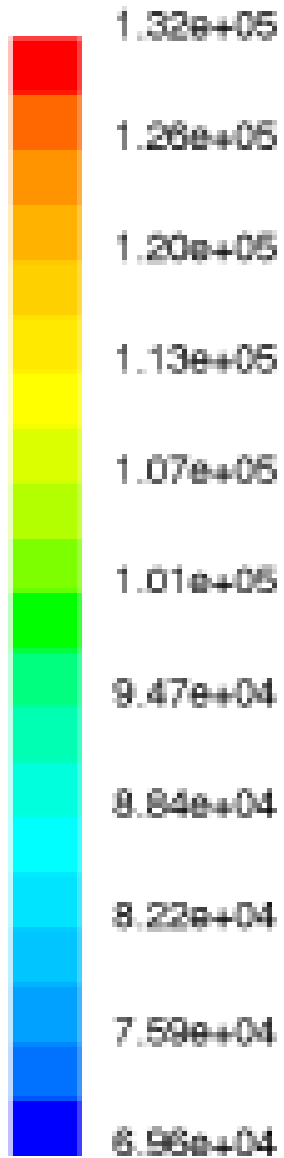
CFD MODELING GEOMETRY



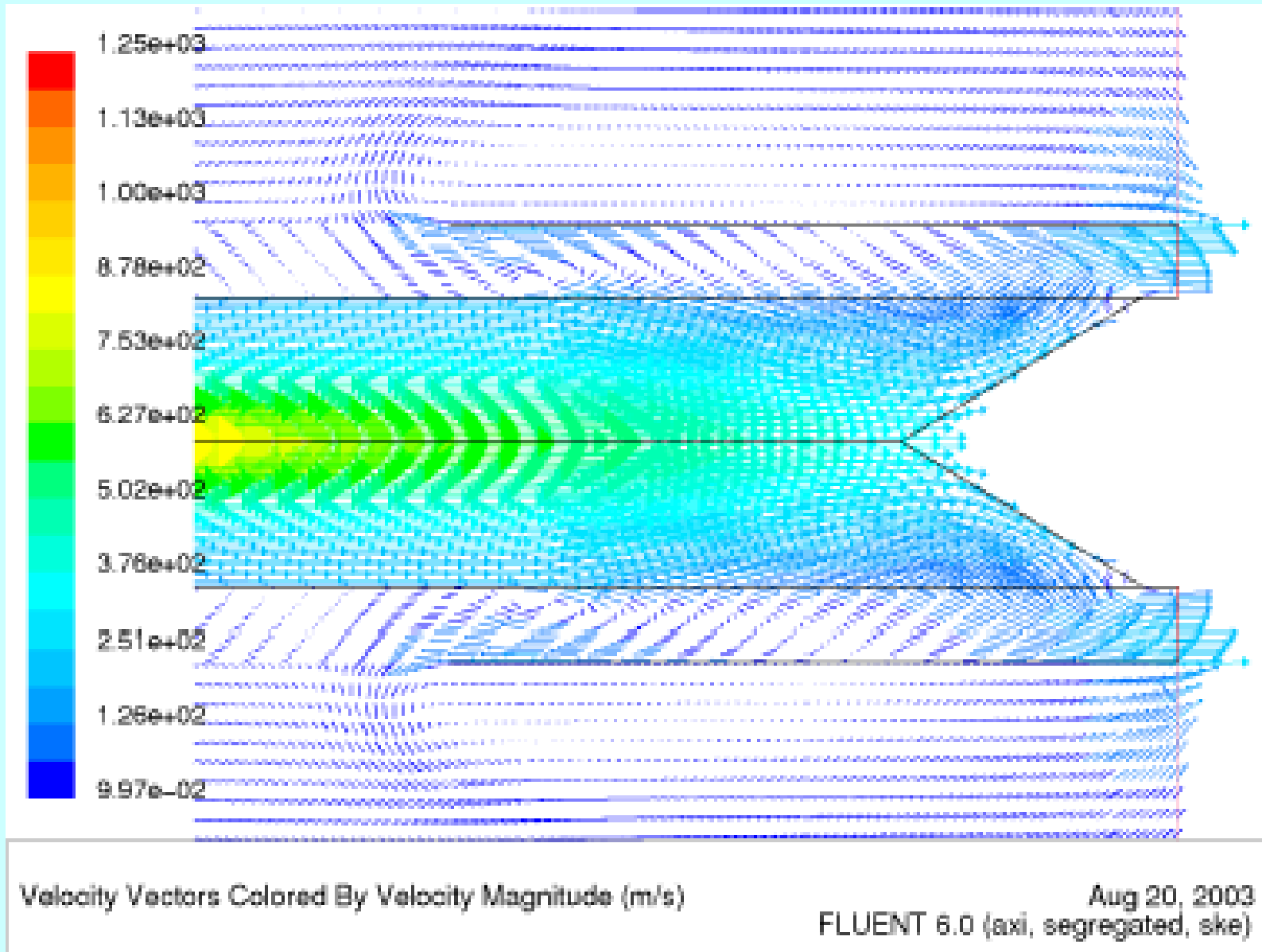
CALCULATED MACH NUMBER



CALCULATED STATIC PRESSURES

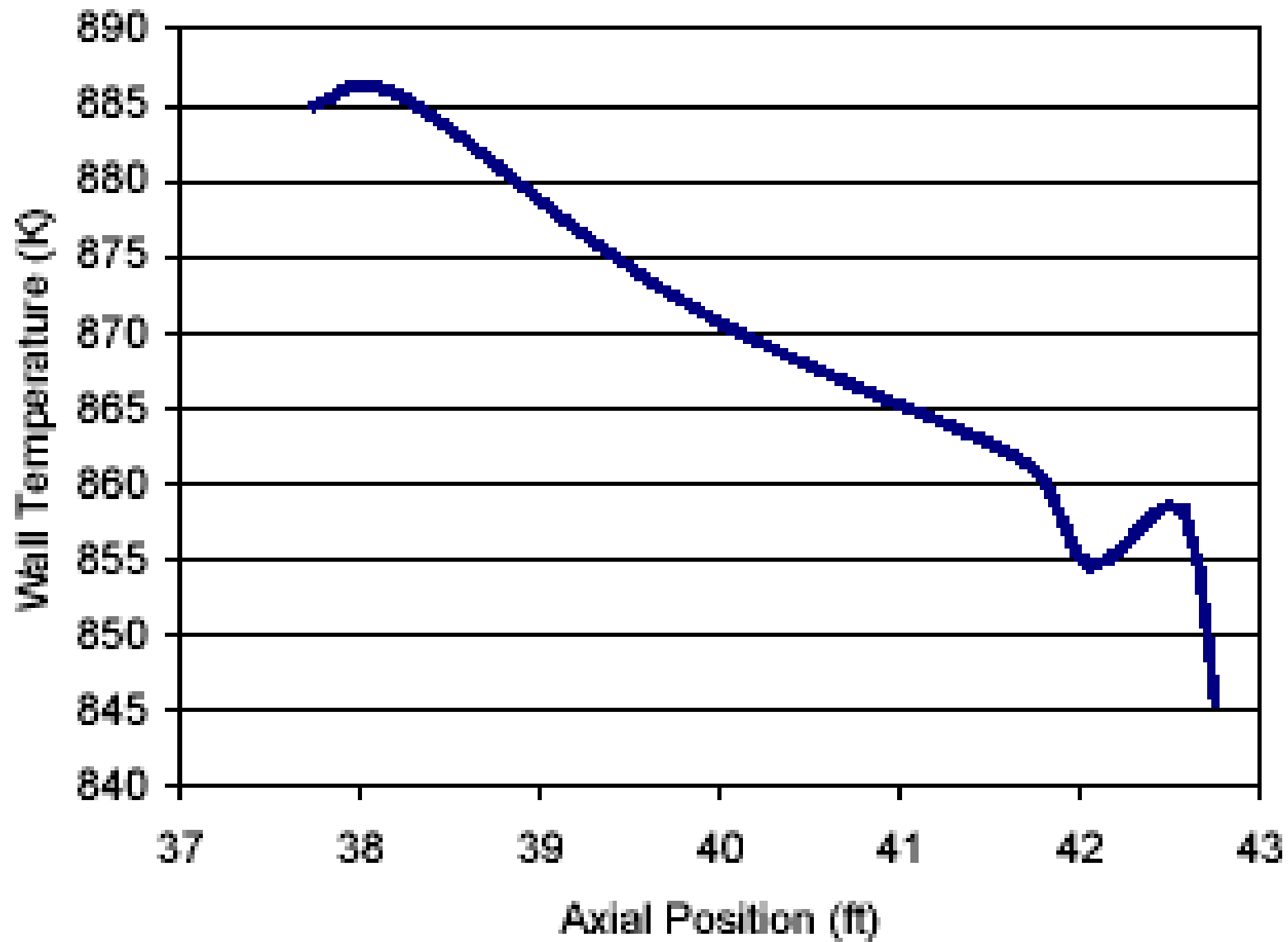


VELOCITY VECTORS

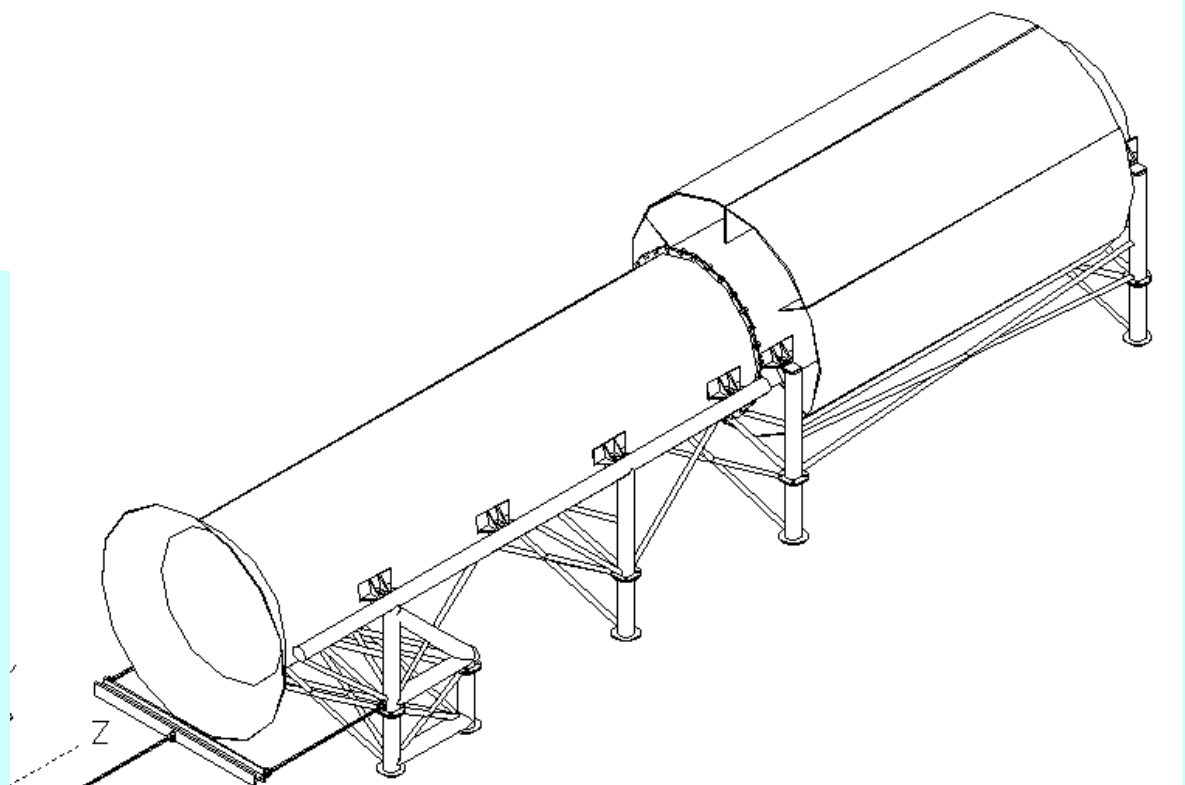
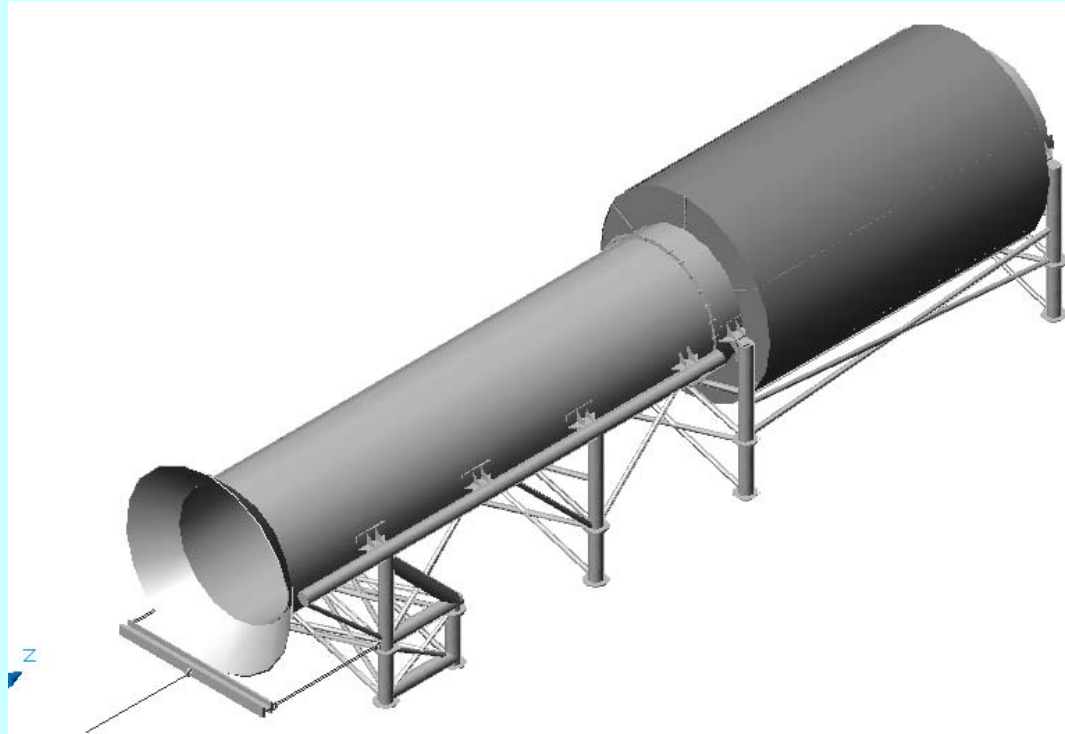
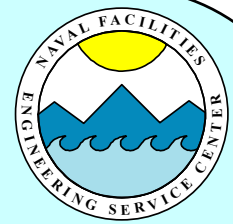




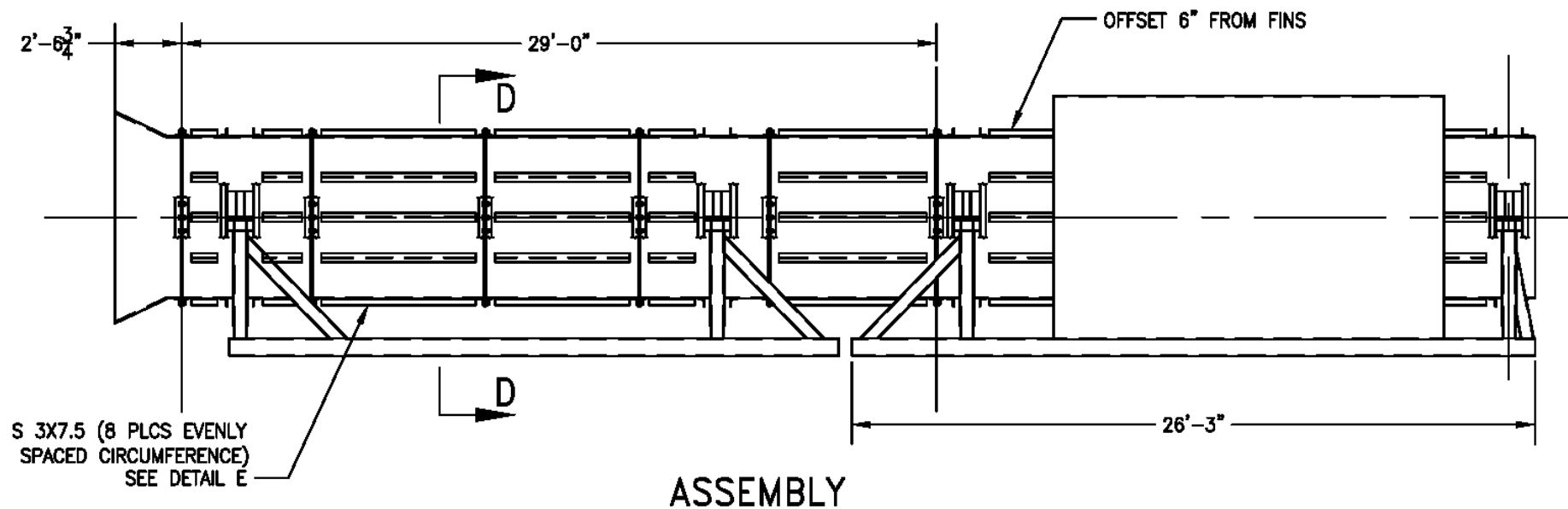
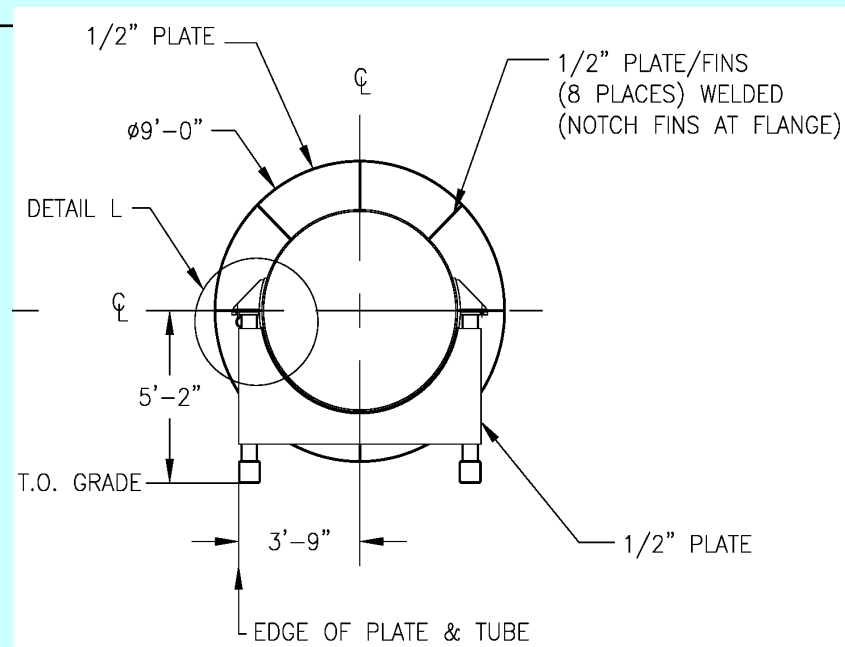
CONE TEMPERATURES



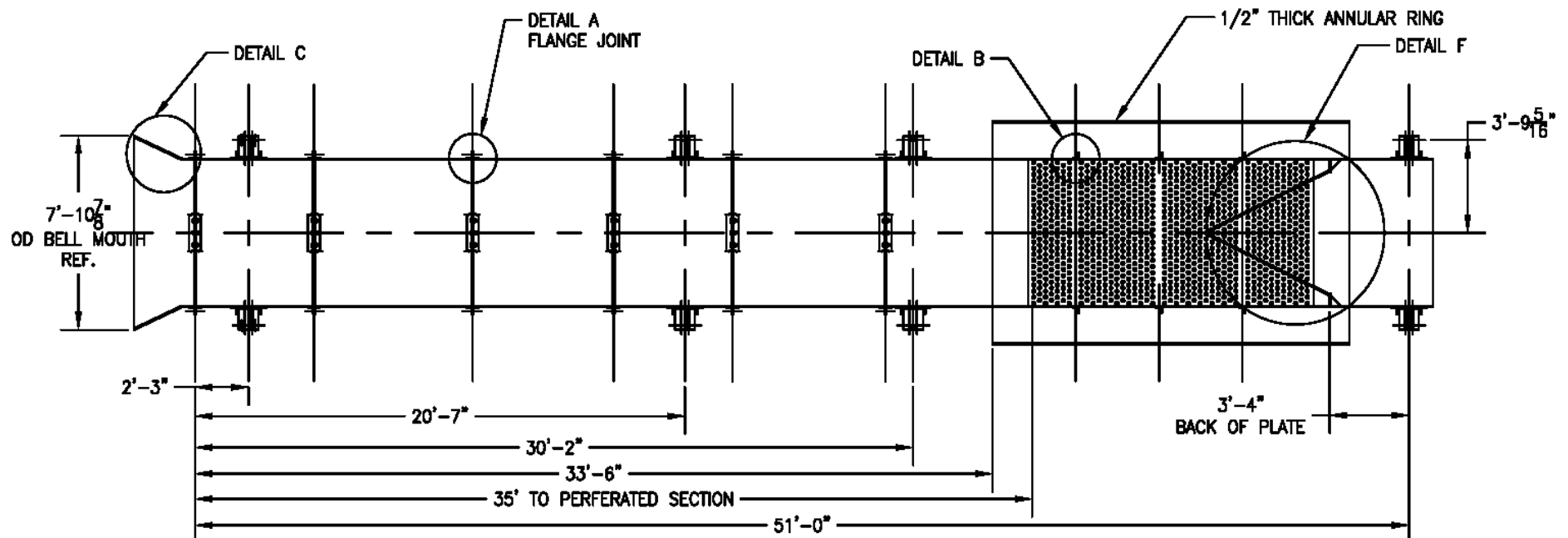
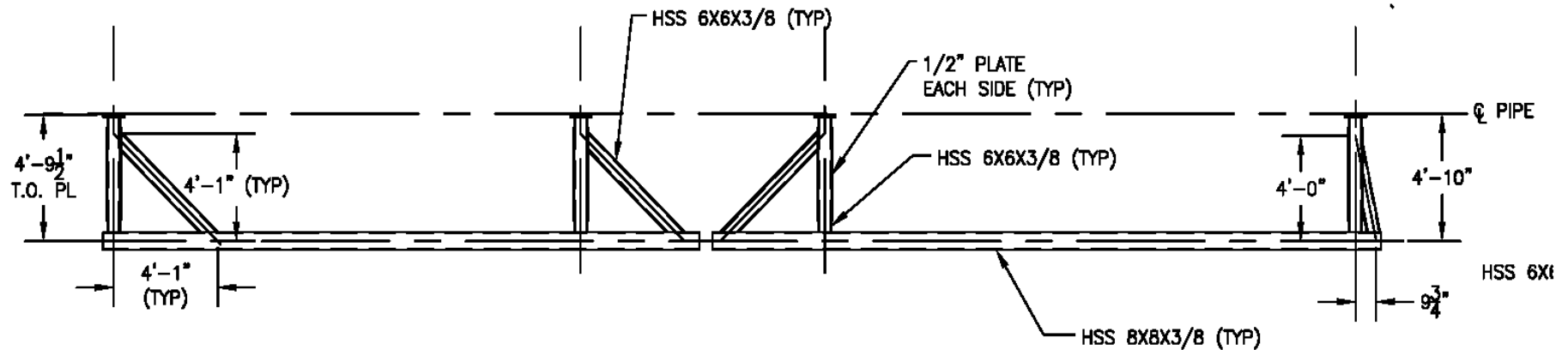
FULL SCALE AAR FOR NOISE REDUCTION



SIDE AND END VIEWS



SUPPORT STAND & INTERNALS

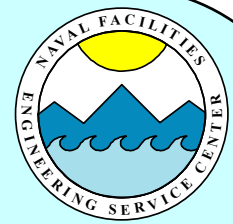




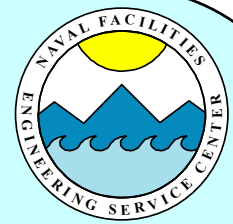
Implementation Plan and Progress

- **Completed demo of Sub-Scale AAR for Noise and NOx reduction.**
- **Completed demo of Small-Scale AAR for NOx and noise reduction.**
- **Complete demo of Full-Scale AAR for noise reduction.**
- **Interface with other Navy aircraft facilities on need for noise reduction for stationary aircraft engine run-up and other possible applications.**
- **Interface with AF on need for noise reduction for stationary engine run-up.**
- **Jet engine manufacturers and commercial airline/transport. associations will be approached for need of this technology.**
- **Technical assistance will be provided to AAR users on as-needed basis.**

Additional Participation and Coordination



- **NAVAIR / PATUXENT RIVER**



Summary

- **SUB-SCALE (1 ½" SIMULATED ENGINE) TESTING COMPLETED**
 - Observed and measured broad-band noise reductions of 10-21 dB.
- **SMALL-SCALE (4" ENGINE) TESTING COMPLETED**
 - Measured broad-band noise reductions: 12-35 dB.
- **FULL-SCALE AAR**
 - Computer modeling projects 50% NOx reduction at mil power; > 50% NOx reduction at after-burner power levels.
 - CFD modeling used to provide basis of design for AAR that can be used with F414 engine operating at after-burning conditions.
 - Designed / Acquisition Initiated of F-S AAR for F414 engine.
 - Agreement with NAVAIR to conduct demonstration tests at Patuxent River NAWC in Summer / Fall 2004.